

Bacteria-Impaired Waters
TMDL Project I
SAG Meeting

March 26, 2004

Regional Board Topics

- Status of 303(d) List
- Beneficial Uses/Water Quality Objectives
- Reference Approach
- Wet weather model concepts
- Dry weather model concepts

Status of 303(d) List

- 2004 Update currently in initial phases
- Bacteria-impaired waters re-evaluated concurrently with TMDL development
- De-listing may be recommended

Beneficial Uses/WQO

- Found in Ocean Plan, Basin Plan
 - REC-1: Total Coliform
Fecal Coliform
Enterococcus
E. Coli
 - SHELL: Total Coliform
 - 2002 303(d) List names:
- Single Sample Max =
Designated Beach
- Specific Indicator causing impairment (Creeks)
 - “Bacteria Indicators” (Beach Segments)

Reference Watershed Approach: Interim TMDLs

- *Reference Approach* allows for concentrations of bacteria above the numeric WQO
 - Concept first used by LA Regional Board
 - Same reference watershed used—number of wet days causing exceedances
 - Waste Load Allocations expressed differently

Basin Plan WQOs: Final TMDLs

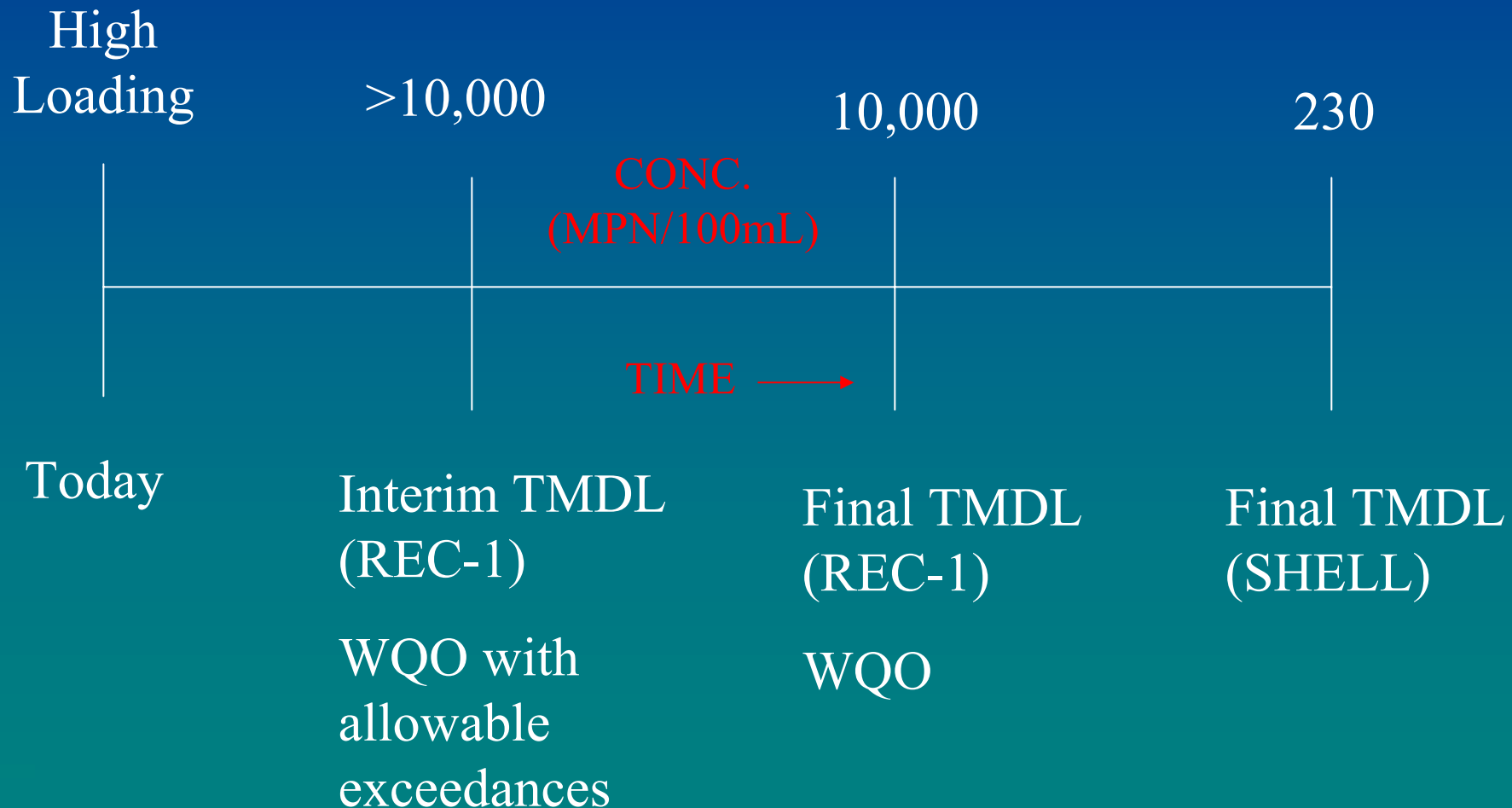
- **Ultimate TMDLs do not incorporate Reference Watershed**
- **No Basin Plan Amendment currently proposed to change existing WQOs**

Wet Weather Model Concepts

BU	INTERIM TMDL	FINAL TMDL
REC-1	Reference Watershed; WQO with allowable exceedances of Single Sample Max	WQO (Single Sample Max)
SHELL	N/A	WQO (Single Sample Max)

Example Implementation Timeline

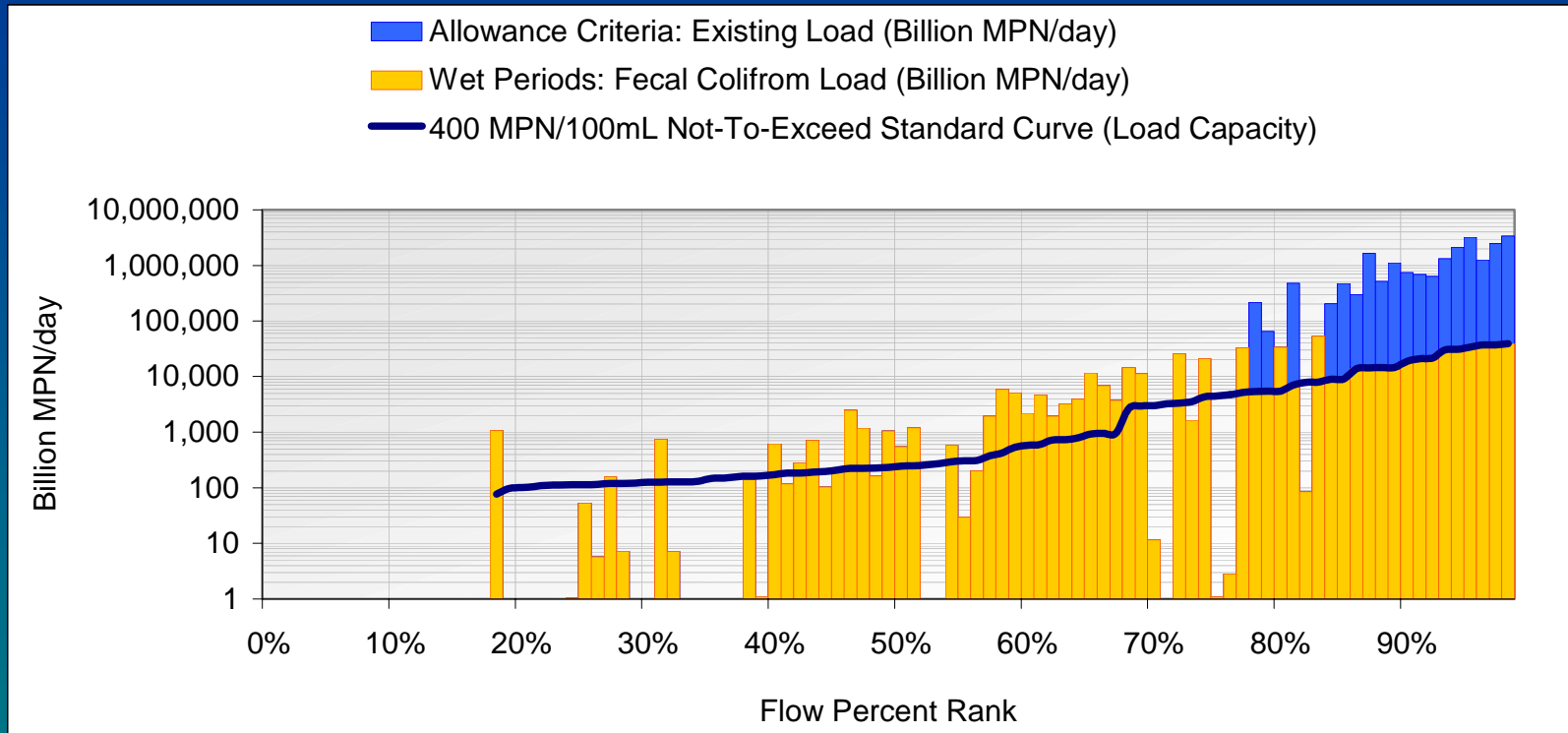
Wet-Weather, Beaches (Total Coliform)



Dry Weather Model Concepts

BU	INTERIM TMDL	FINAL TMDL
REC-1	N/A	WQO (30-Day Geometric Mean)
SHELL	N/A	WQO (30-Day Geometric Mean)

Wet Weather Loading Analysis – Interim Reductions



Fecal Coliform Loading Summary	Value	Units
Waste Load Allocation (Load capacity below WQO curve)	467,420	Billion MPN/Year
Total Load for Existing Condition	21,283,828	Billion MPN/Year
Total Load Using Allowance Criteria	713,335	Billion MPN/Year
Non-allowable Exceedance Load	282,742	Billion MPN/Year
Required Annual Load Reduction	39.6%	Percentage
Wet Day Exceedances	50	None
Allowable Wet Day Exceedances	19	None
Excess Wet Day Exceedances	31	None

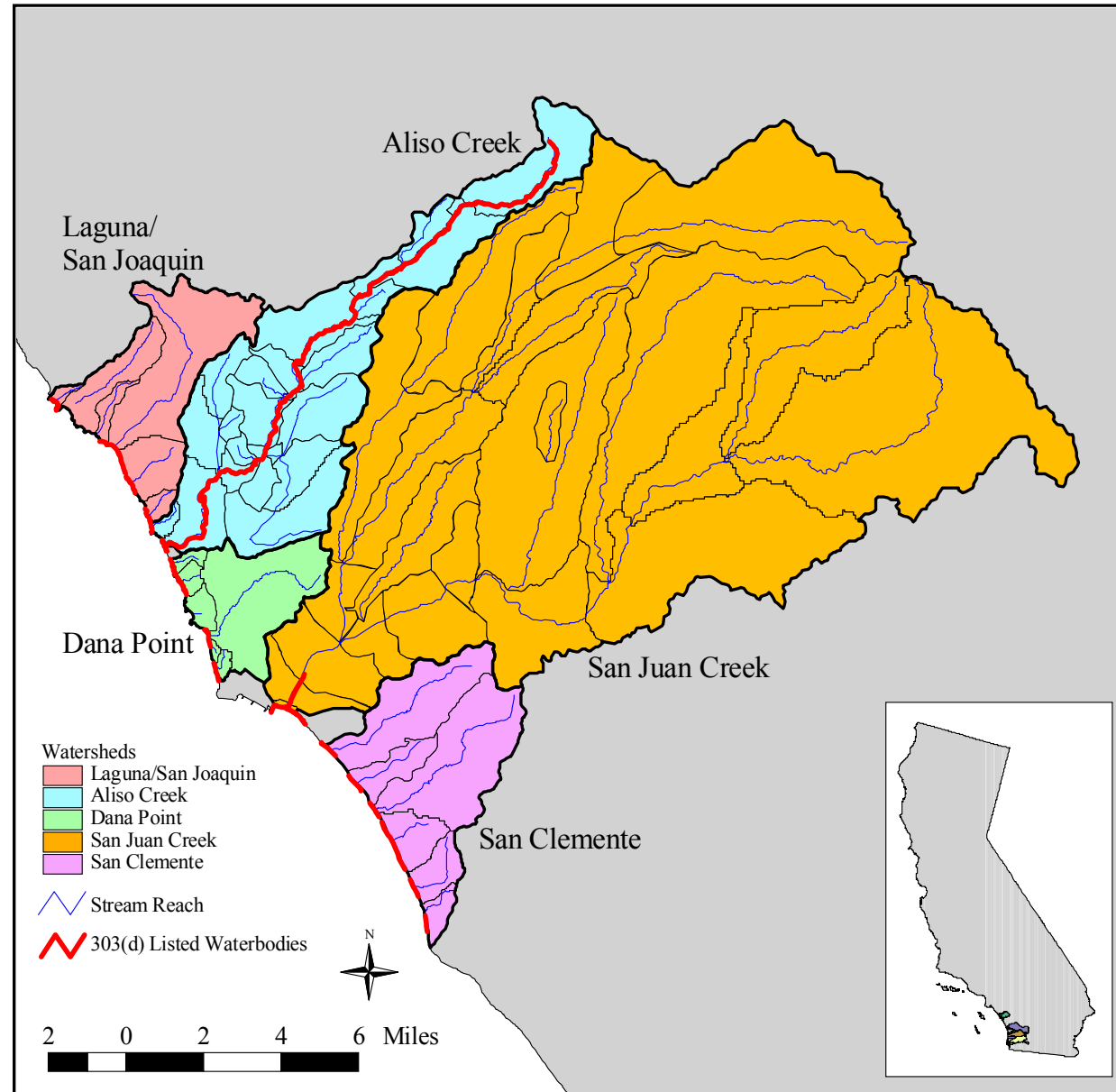
Bacteria TMDLs for Beaches and Creeks of the San Diego Region

Technical Approach Summary



Watersheds in Orange County

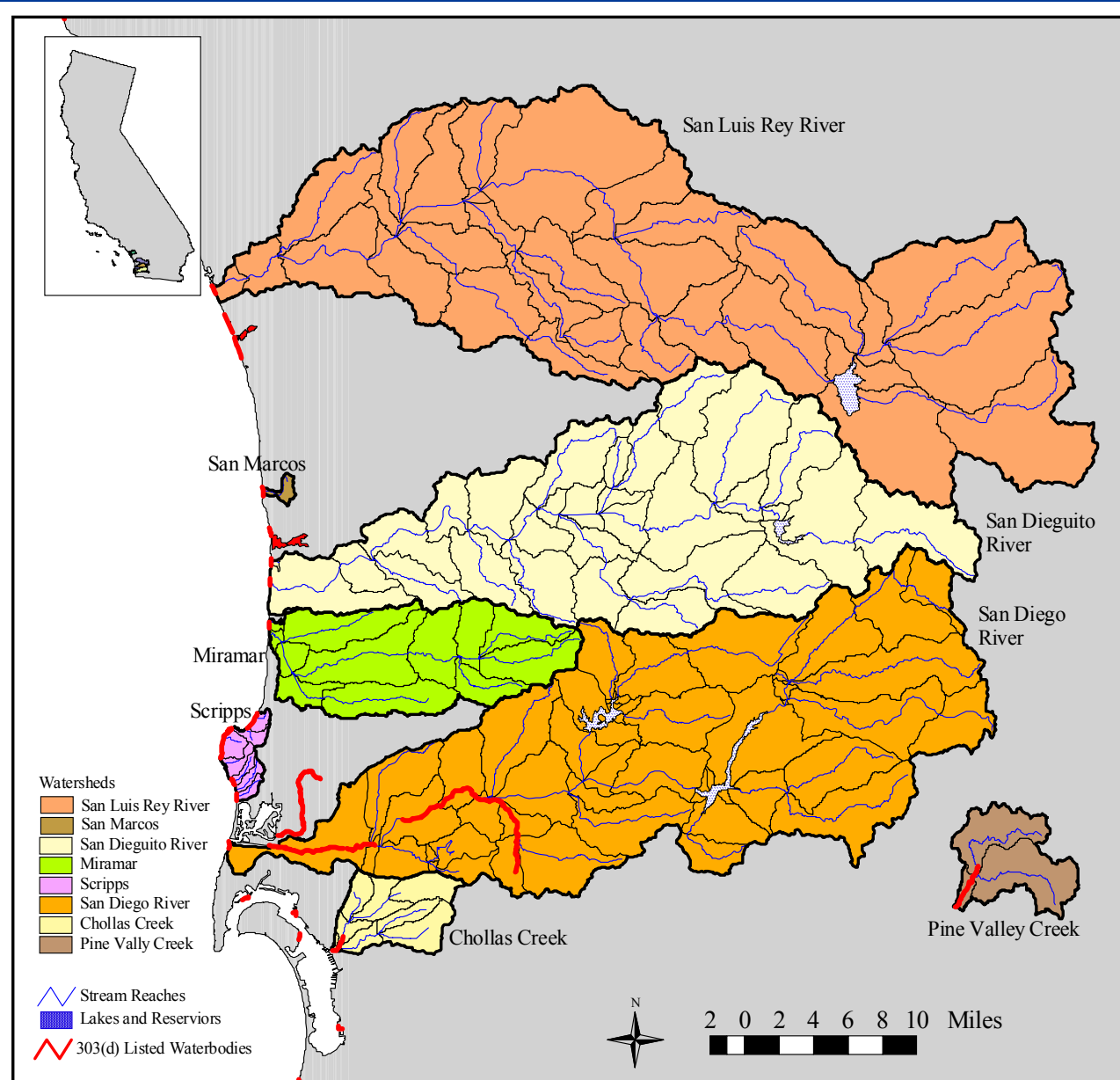
- Watersheds impacting:
 - Multiple beaches
 - Aliso Creek
 - San Juan Creek



Watersheds in San Diego County

- Watersheds impacting:

- Multiple beaches
- San Diego River
- Forrester Creek
- San Juan Creek
- Chollas Creek
- Pine Valley Creek



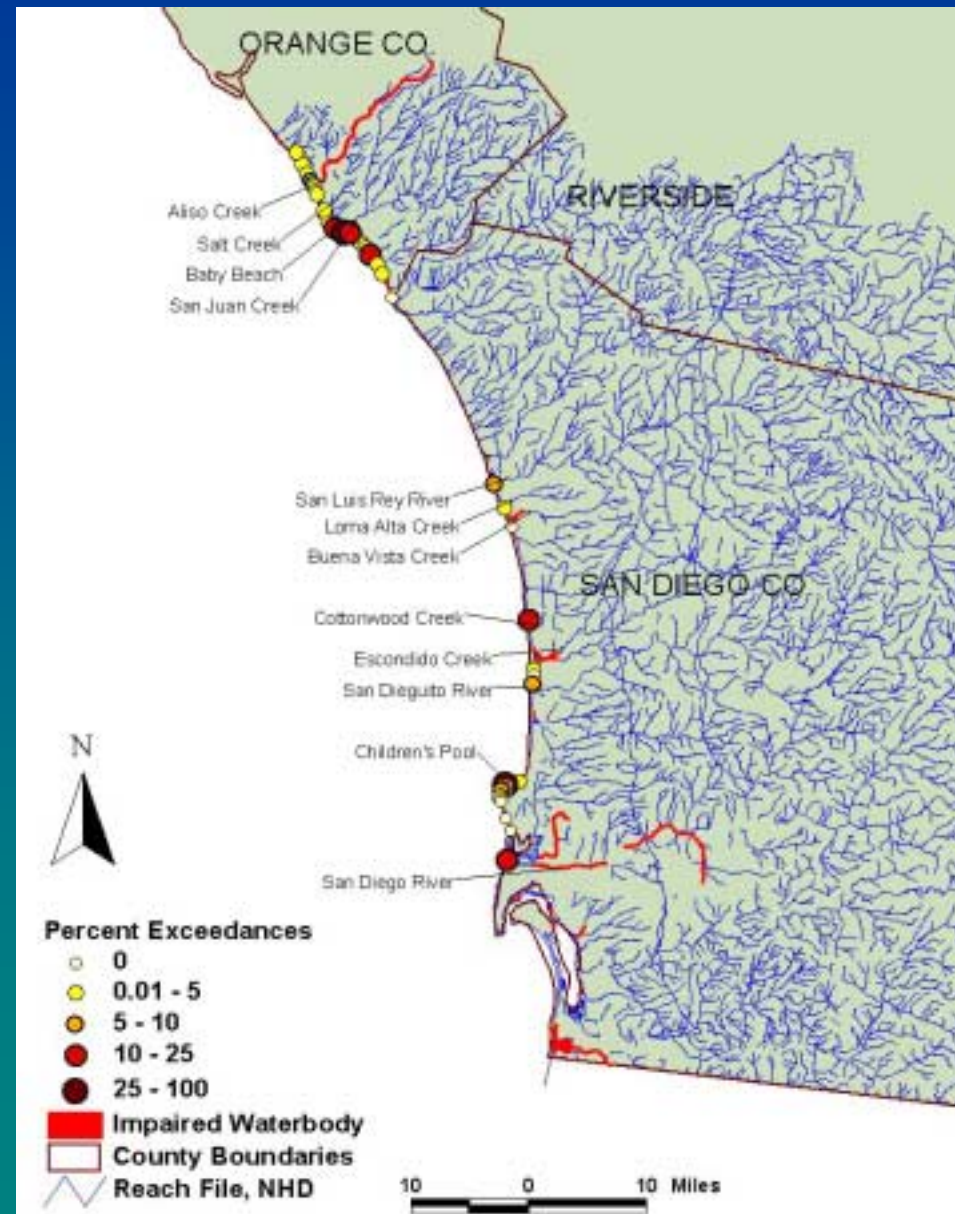
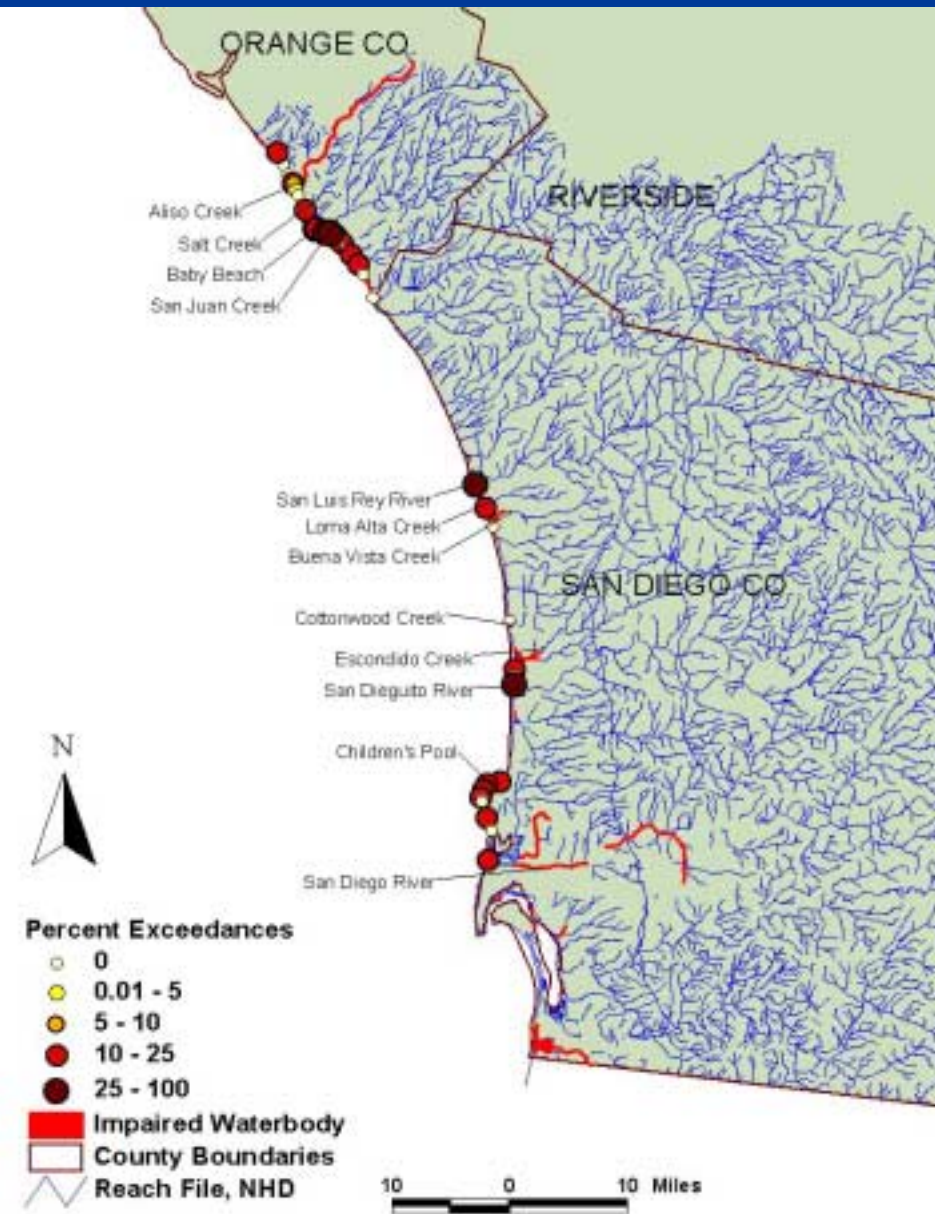
Review of Shoreline Water Quality Data

- Shoreline monitoring data were divided into wet and dry conditions
 - Analysis of local rainfall data
 - Wet condition consistent with the California DEH's General Advisory to avoid contact (72 hours after 0.2 inch or more of rain)
- For each condition, the exceedances of the single sample water quality objectives were quantified
- Exceedances of FC, TC, and ENT objectives were observed during both wet and dry conditions

Review of Fecal Coliform Data (REC-1 Exceedances)

Wet Conditions

Dry Conditions



Consideration for Strategy Development

- Method of transport of bacteria vary between wet and dry conditions
- Separate watershed-based approaches required to address each condition
- Critical point for TMDL development at the mouth of watersheds draining to beaches
 - Discharge considered critical point, with dilution occurring at increased distance from the discharge point
 - Protection at the point of discharge ensures protection in the surf zone

Wet Weather Approach

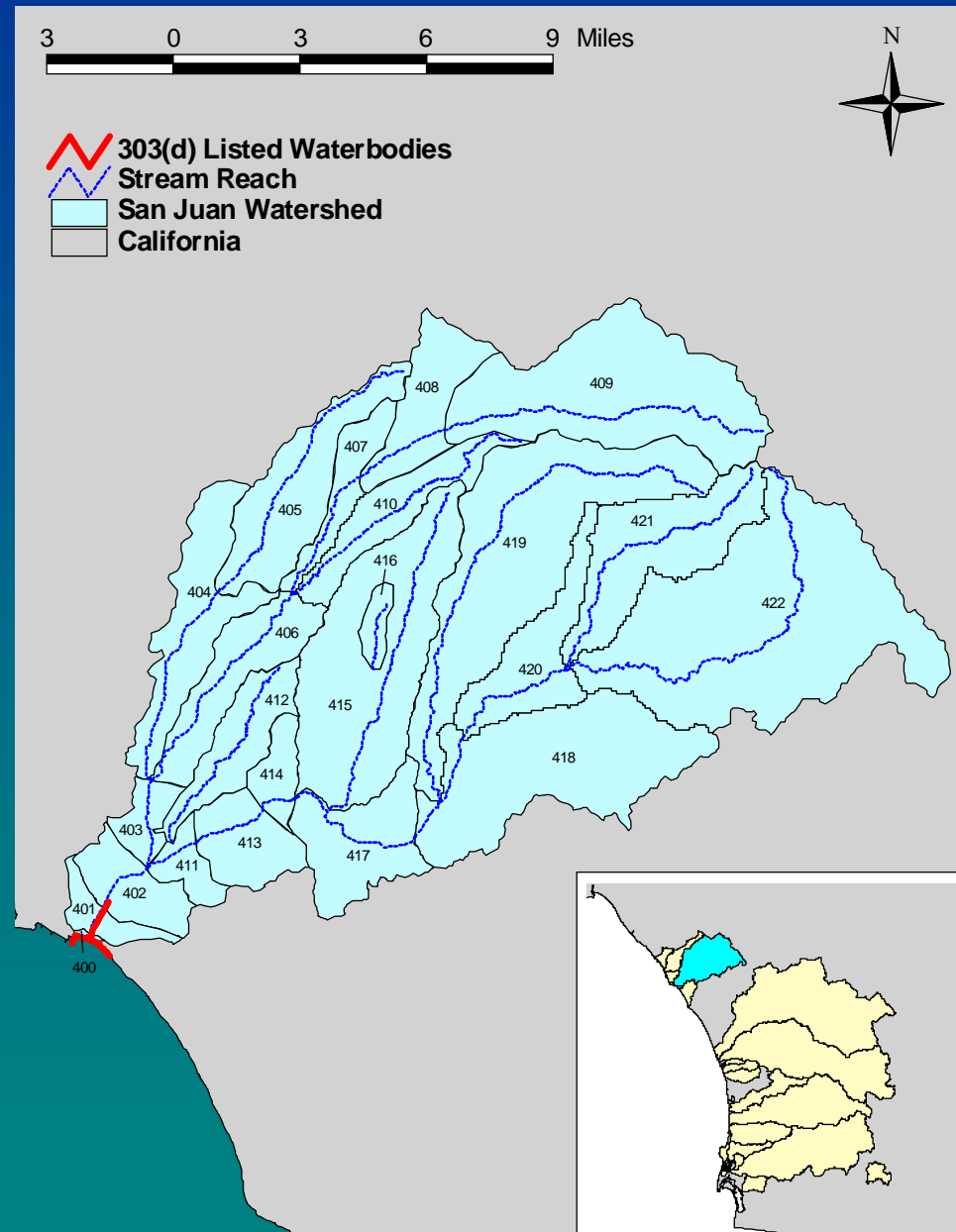
- Watershed model of San Diego region to address TMDLs for impaired streams and beaches
 - Streams modeled directly in watershed model
 - Beaches addressed using critical points at point of discharge
- Endpoints based on:
 - REC-1 and SHELL water quality objectives
 - Reference exceedance days (approach used for Santa Monica Bay)

Watershed Model - LSPC

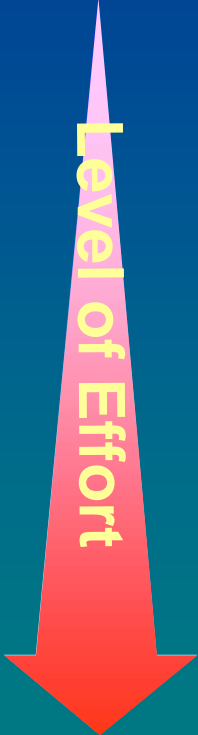
- Loading Simulation Program, C++
- Developed and maintained by EPA, with support from Tetra Tech
- Streamlined HSPF algorithms for pervious and impervious land flow and pollutant transport, coded with Visual C++ in an object-oriented environment
- LSPC = HSPF with no inherent modeling size or operational limits
- Visual C++ programming architecture allows for seamless integration with modern-day, widely available software such as Microsoft Access, and Excel
- Tailored for TMDL calculation
- Highly adaptable design and programming architecture that allows for modular additions and/or improvements (e.g., hydraulic modification, BMP simulation)

Considerations for Watershed Model Configuration

- Streams locations and physical features
- Locations of monitoring stations
- Watersheds delineated into subwatersheds based on:
 - CALWTR 2.2 coverage
 - Monitoring stations
- Meteorological data assigned to each subwatershed
- Land use distribution quantified for each subwatershed
- Hydrologic soil groups assigned to each subwatershed



Hydrology Calibration

- 
- **Analytical Considerations**
 - annual water balance
 - seasonal / monthly distribution
 - storm flows
 - baseflow
 - distribution of hydrograph components

Hydrology Calibration

LSPC Simulated Flow

REACH OUTFLOW FROM SUBBASIN 1801

6-Year Analysis Period: 1/1/1991 - 12/31/1996

Flow volumes are (inches/year) for upstream drainage area

Observed Flow Gage

USGS 11023000 SAN DIEGO R A FASHION VALLEY AT SAN DIEGO CA

San Diego County, California

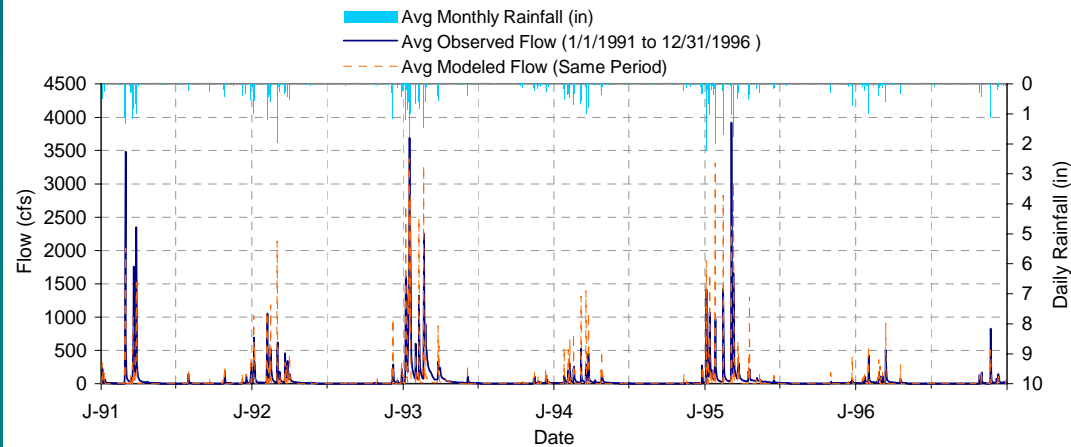
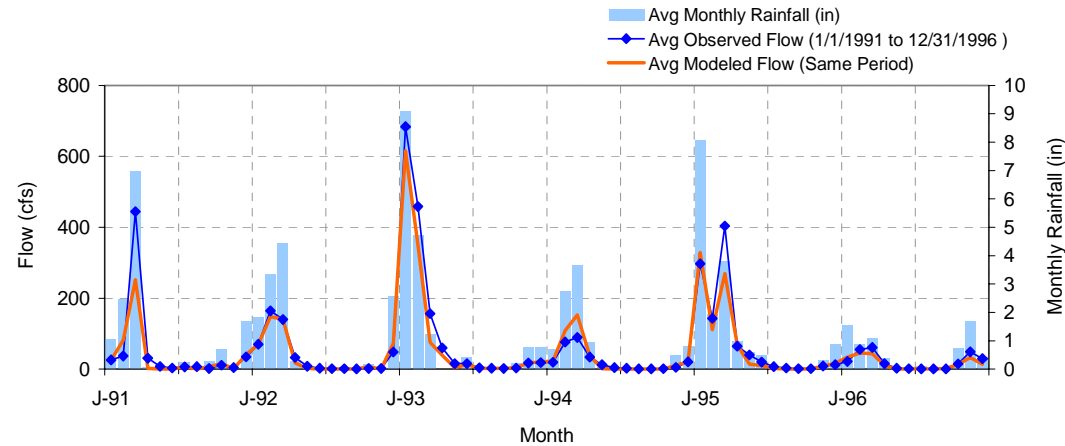
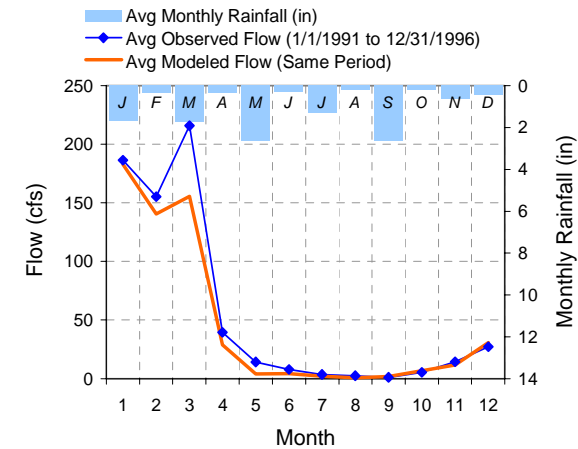
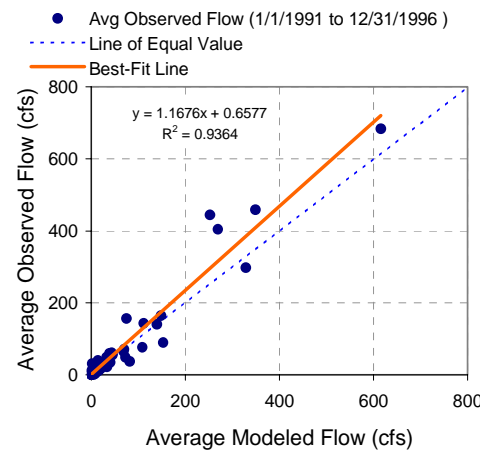
Hydrologic Unit Code 18070304

Latitude 32°45'54", Longitude 117°10'04" NAD27

Drainage area 429 square miles

Total Simulated In-stream Flow:	1.49	Total Observed In-stream Flow:		1.77
Total of simulated highest 10% flows:	1.42	Total of Observed highest 10% flows:		1.38
Total of Simulated lowest 50% flows:	0.00	Total of Observed Lowest 50% flows:		0.04
Simulated Summer Flow Volume (months 7-9):	0.01	Observed Summer Flow Volume (7-9):		0.02
Simulated Fall Flow Volume (months 10-12):	0.13	Observed Fall Flow Volume (10-12):		0.12
Simulated Winter Flow Volume (months 1-3):	1.25	Observed Winter Flow Volume (1-3):		1.46
Simulated Spring Flow Volume (months 4-6):	0.10	Observed Spring Flow Volume (4-6):		0.16
Total Simulated Storm Volume:	1.43	Total Observed Storm Volume:		1.26
Simulated Summer Storm Volume (7-9):	0.01	Observed Summer Storm Volume (7-9):		0.01
Errors (Simulated-Observed)	Current Run (n)	Recommended Criteria	Run (n-1)	Run (n-2)
Error in 10% highest flows:	2.65	15		
Error in storm volumes:	12.33	20		

Hydrology Calibration



Hydrology Calibration

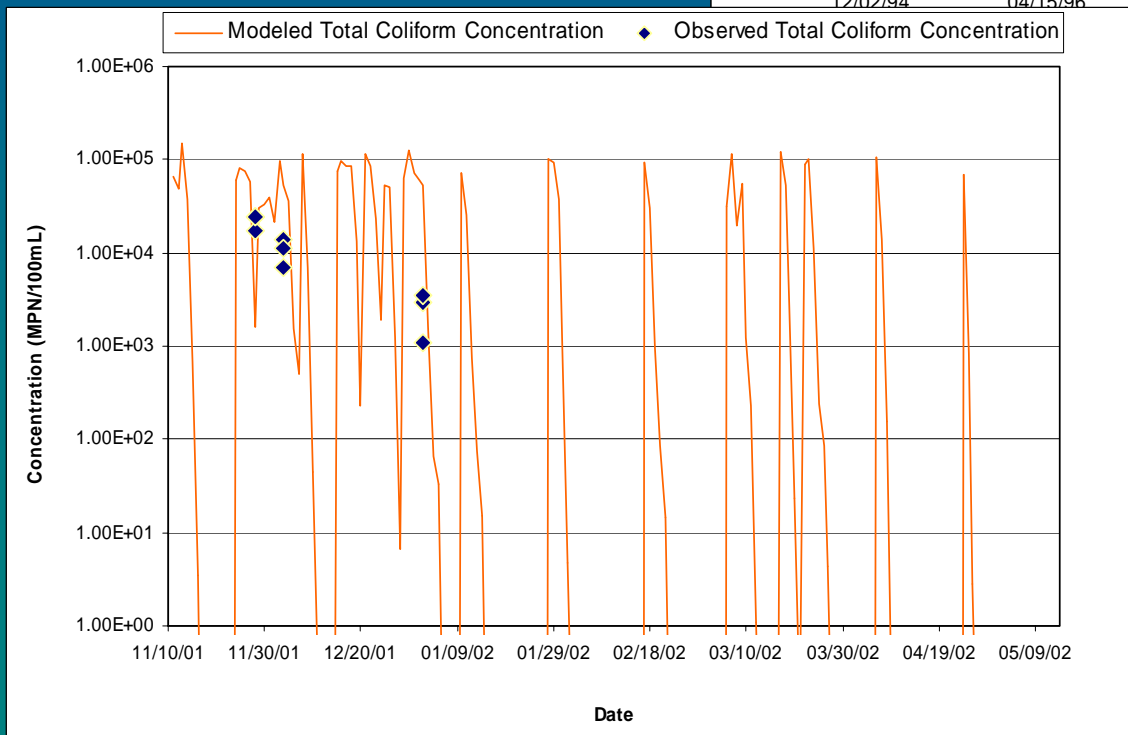
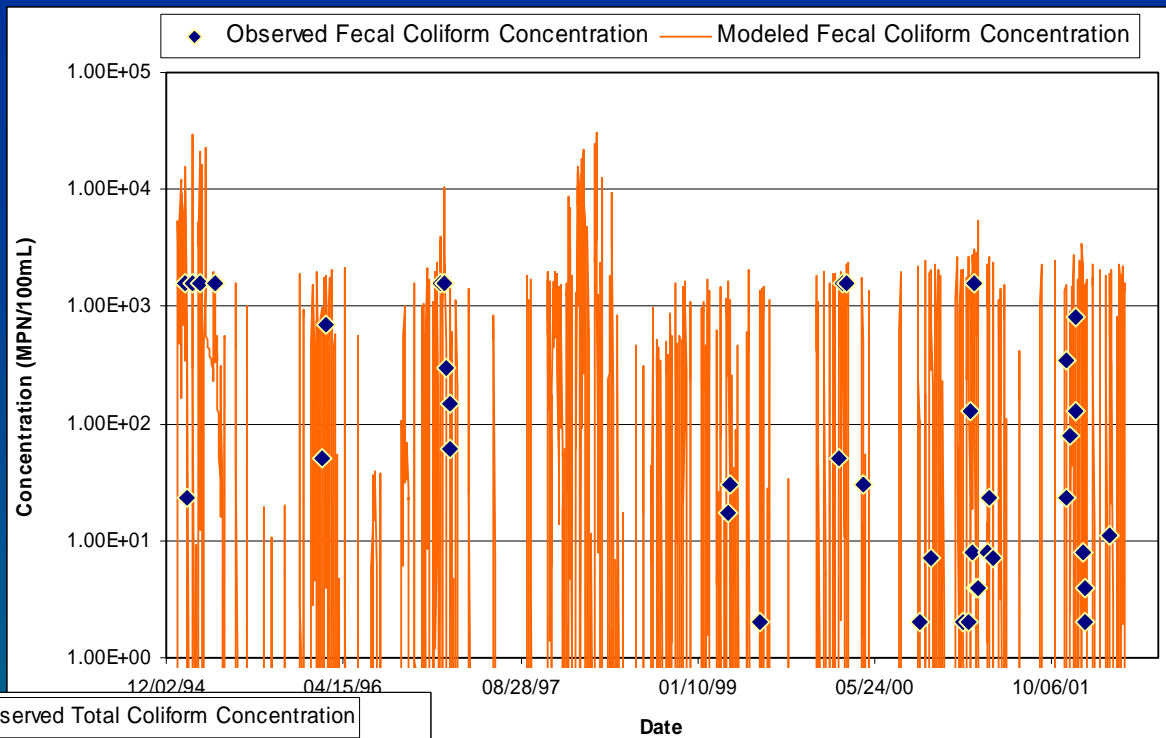
- 7 watersheds represented
- 11 USGS stations used for calibration
- 13 USGS stations used for validation

Station Number	Station Name	Historical Record	Selected Calibration Period	Selected Validation Period	Watershed and Model Subwatershed
11022480	San Diego River at Mast Road near Santee, CA	5/1/1912 - 9/30/2002	1/1/1991 - 12/31/1996	1/1/1997 - 12/31/2001	San Diego River (1805)
11023000	San Diego River at Fashion Valley at San Diego, CA	1/18/1982 - 9/30/2002	1/1/1991 - 12/31/1996	1/1/1997 - 12/31/2001	San Diego River (1801)
11023340	Los Penasquitos Creek near Poway, CA	10/1/1964 - 9/30/2002	1/1/1991 - 12/31/1996	1/1/1997 - 12/31/2001	Miramar (1406)
11025500	Santa Ysabel Creek near Ramona, CA	2/1/1912 - 9/30/2002	1/1/1991 - 12/31/1996	1/1/1997 - 12/31/2001	San Dieguito (1316)
11028500	Santa Maria Creek near Ramona, CA	12/1/1912 - 9/30/2002	1/1/1991 - 12/31/1996	1/1/1997 - 12/31/2001	San Dieguito (1324)
11042000	San Luis Rey River at Oceanside, CA	10/1/1912 - 11/10/1997; 4/29/1998 - 9/30/2002	9/1/1993 - 8/31/1997	5/1/1998 - 4/30/2002	San Luis Rey (702)
11042400	Temecula Creek near Aguanga, CA	8/1/1957 - 9/30/2002	1/1/1991 - 12/31/1996	1/1/1997 - 12/31/2001	Santa Margarita (658)
11044300	Santa Margarita River at FPUD Sump near Fallbrook, CA	10/1/1989 - 9/30/2002	1/1/1991 - 12/31/1996	1/1/1997 - 12/31/2001	Santa Margarita (615)
11046000	Santa Margarita River at Ysidora, CA	3/1/1923 - 2/25/1999; 10/1/2001 - 9/30/2002	1/1/1991 - 12/31/1995	1/1/1996 - 12/31/1998	Santa Margarita (602)
11046530	San Juan Creek at La Novia Street Bridge near San Juan Capistrano, CA	10/1/1985 - 9/30/2002	1/1/1991 - 12/31/1996	1/1/1997 - 12/31/2001	San Juan (411)
11047300	Arroyo Trabuco near San Juan Capistrano, CA	10/1/1970 - 9/30/1989; 10/1/1995 - 9/30/2002	10/1/1995 - 4/30/1999	5/1/1999 - 4/30/2002	San Juan (403)
11022350	Forester Creek near El Cajon, CA	10/1/1993 - 9/30/2002	none (insufficient period of record)	1/1/1991 - 9/30/1993	San Diego River (1843)
11039800	San Luis Rey River at Couser Canyon Bridge near Pala, CA	10/1/1986 - 1/4/1993	none (insufficient period of record)	1/1/1991 - 12/31/1992	San Luis Rey (711)

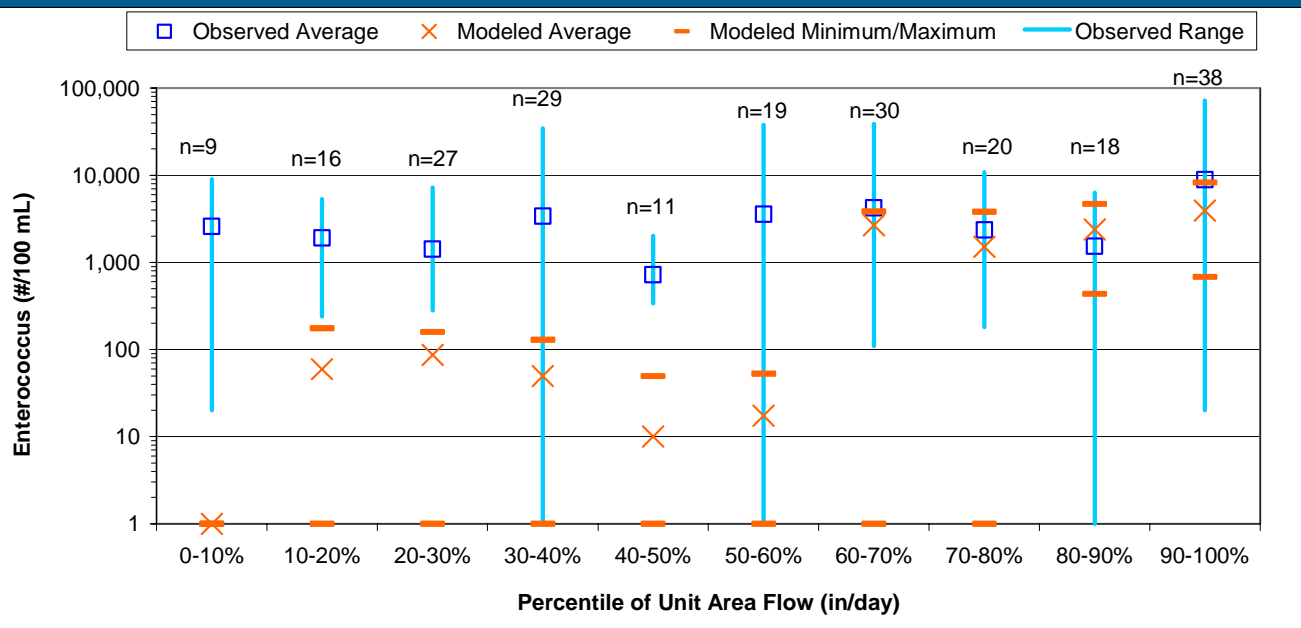
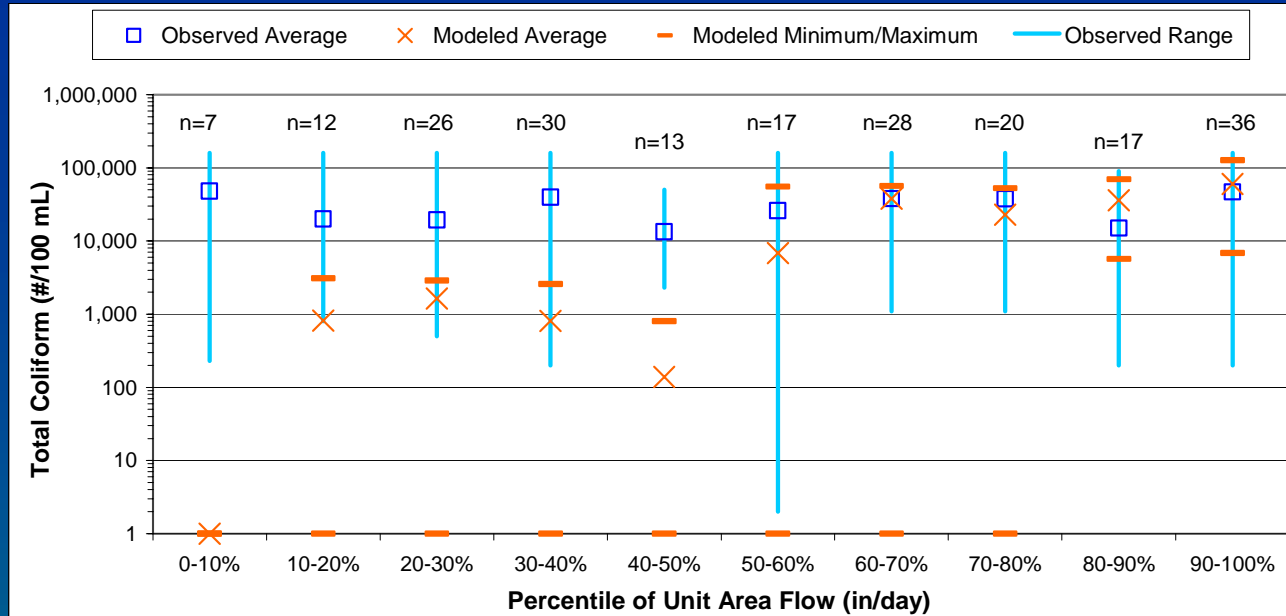
Issues with Watershed Water Quality

- Build-up and wash-off of bacteria simulated using previously calibrated, land use specific model parameters determined for other TMDL modeling studies in Southern CA:
 - Santa Monica Bay (developed by SCCWRP)
 - LA River
 - San Gabriel River
 - San Jacinto River
- Model parameters validated for San Diego Region through comparison with instream water quality data

Water Quality Calibration



Water Quality Calibration



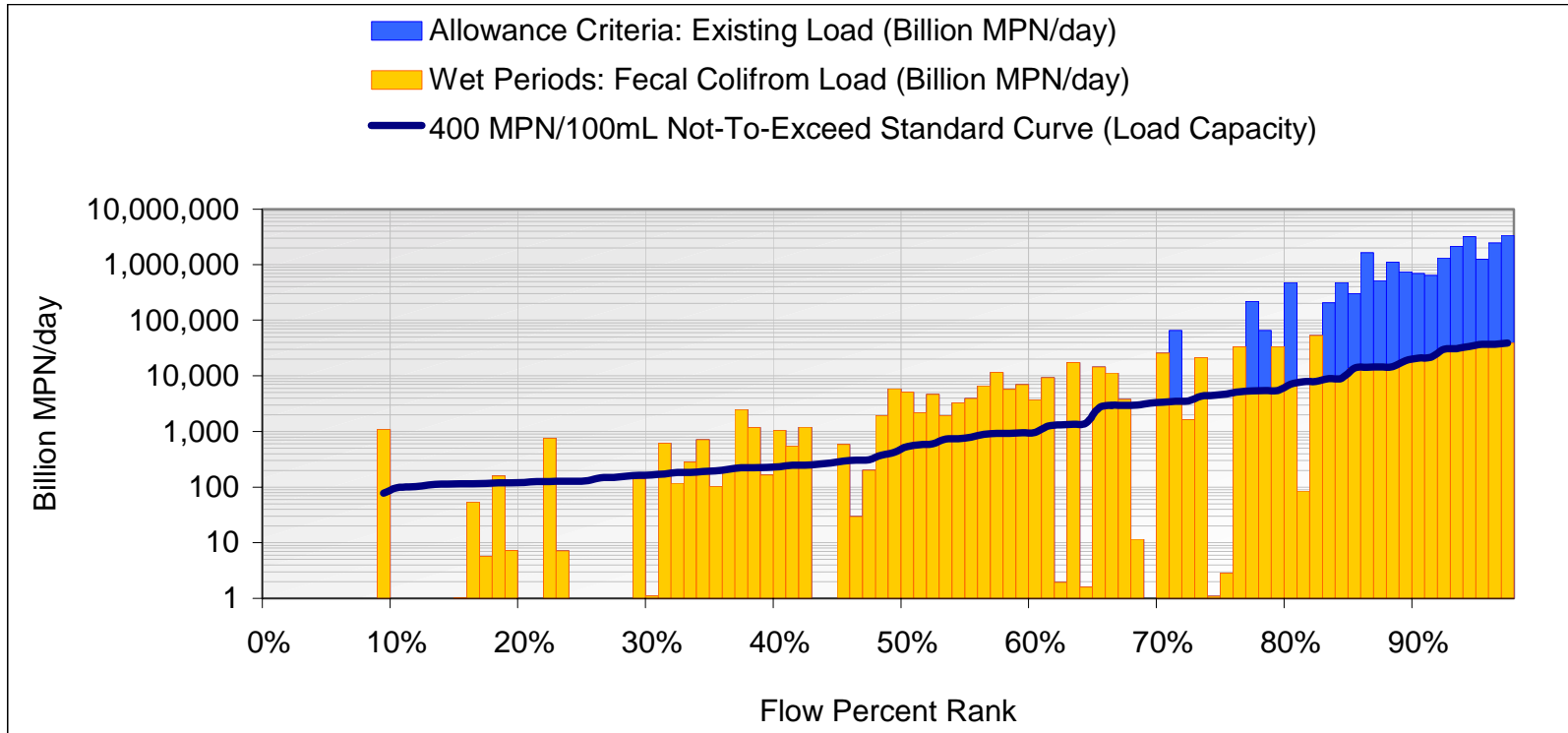
Model Application

- Simulated a critical wet year (1993) for estimation of daily bacteria loads for each watershed impacting impaired waterbodies
- Compared model results to targets for TMDL calculations

Wet Weather TMDL Targets

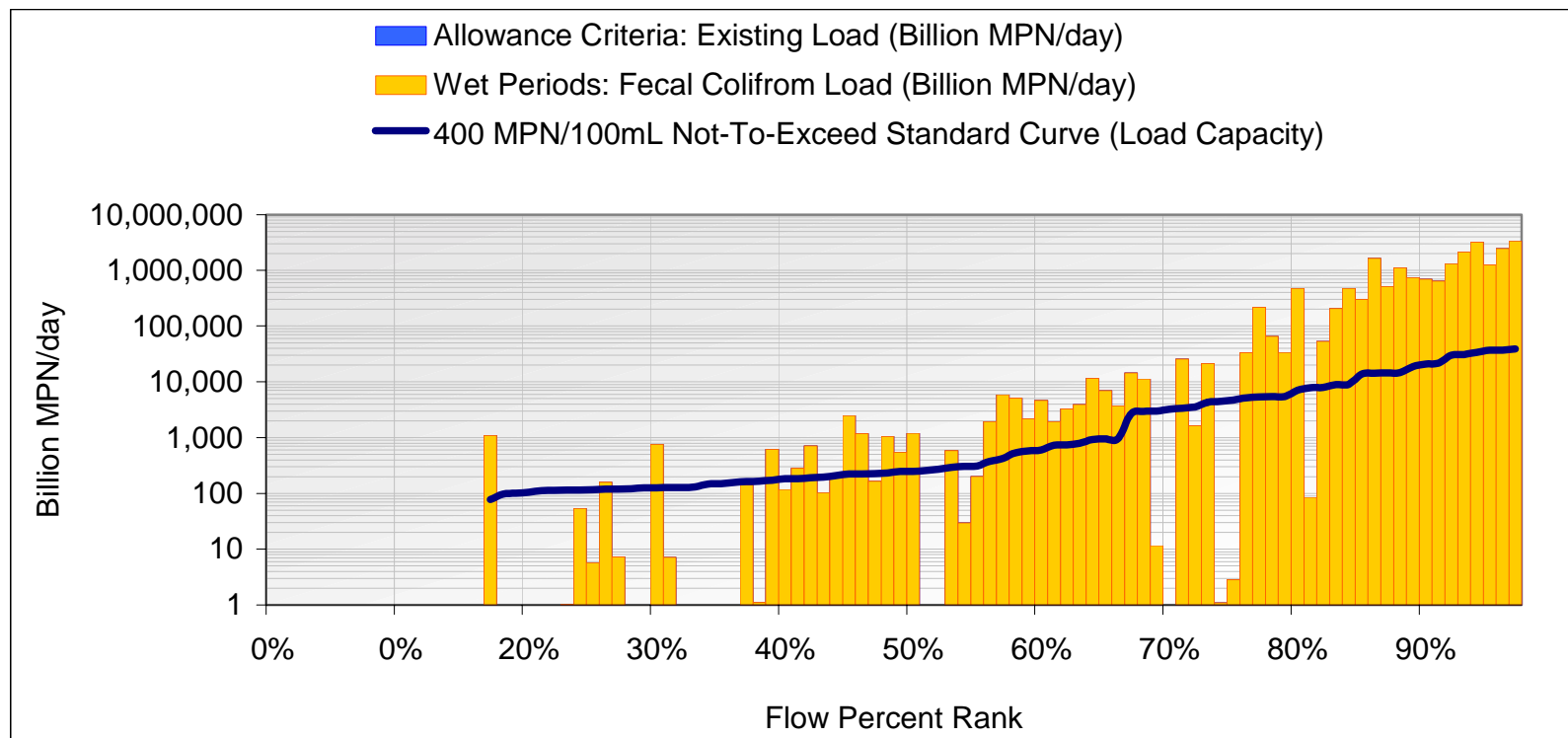
- No suitable reference watershed identified in San Diego Region with sufficient data to define wet reference conditions
- TMDL targets based on Basin Plan water quality objectives:
 - Beaches: REC-1 for FC and ENT; SHELL for TC
 - Inland Surface Waters: REC-1 for FC, TC, and ENT
- Interim implementation targets to provide sufficient time for further study
 - Allowable exceedance frequencies based on LA Region reference watershed
 - REC-1 for TC

Wet Weather Loading Analysis – Interim Reductions



Fecal Coliform Loading Summary	Value	Units
Waste Load Allocation (Load capacity below WQO curve)	467,420	Billion MPN/Year
Total Load for Existing Condition	21,283,828	Billion MPN/Year
Total Load Using Allowance Criteria	713,335	Billion MPN/Year
Non-allowable Exceedance Load	282,742	Billion MPN/Year
Required Annual Load Reduction	40%	Percentage
Wet Day Exceedances	50	None
Allowable Wet Day Exceedances	19	None
Excess Wet Day Exceedances	31	None

Wet Weather Loading Analysis – TMDL Reductions

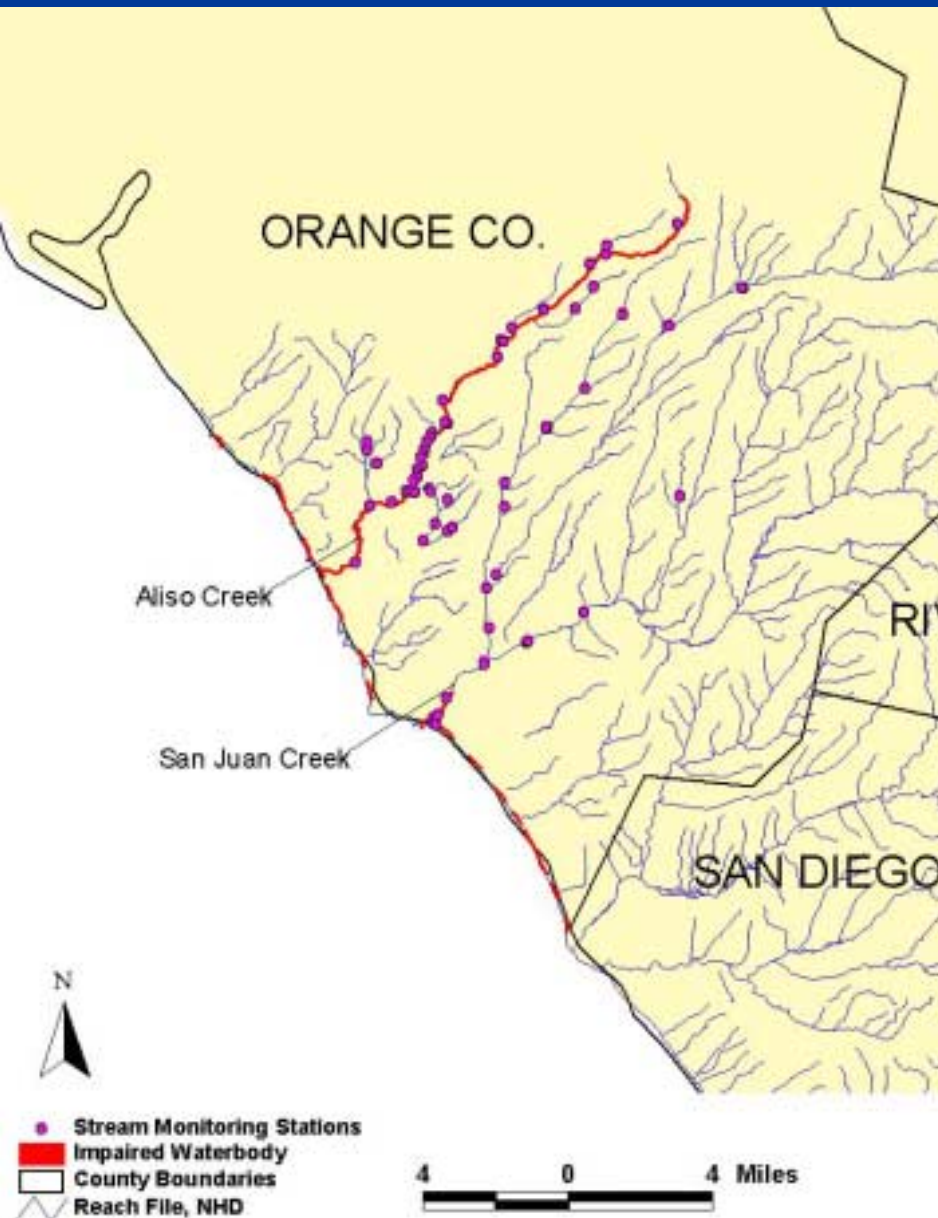


Fecal Coliform Loading Summary	Value	Units
Waste Load Allocation (Load capacity below WQO curve)	467,420	Billion MPN/Year
Total Load for Existing Condition	21,283,828	Billion MPN/Year
Total Load Using Allowance Criteria	21,283,828	Billion MPN/Year
Non-allowable Exceedance Load	20,853,235	Billion MPN/Year
Required Annual Load Reduction	98%	Percentage
Wet Day Exceedances	50	None
Allowable Wet Day Exceedances	0	None
Excess Wet Day Exceedances	50	None

Dry Weather Approach

- Watershed model of San Diego Region to address TMDLs for impaired streams and beaches
 - Loads estimated using empirical model based on data analyses
 - Streams modeled using simplified plug flow model
- TMDLs developed based on critical points at mouth of streams
- Endpoints based on:
 - REC-1/SHELL water quality objectives

Dry Weather Watershed Data



Dry Weather Flow Data Analysis

- Analysis was performed to determine relationship between dry flows and land use within respective subwatersheds
- Average flows determined where data was plentiful
 - 27 stations in Aliso Creek
 - 3 stations in Rose Creek
 - 2 stations in Tecolote Creek
- Multivariable regression analysis performed relating land use areas to flow ($R^2 = 0.78$)

$$Q = (A_{1400} \times 0.00168) + (A_{4000} \times 0.000256) - (A_{1500} \times 0.00141)$$

where

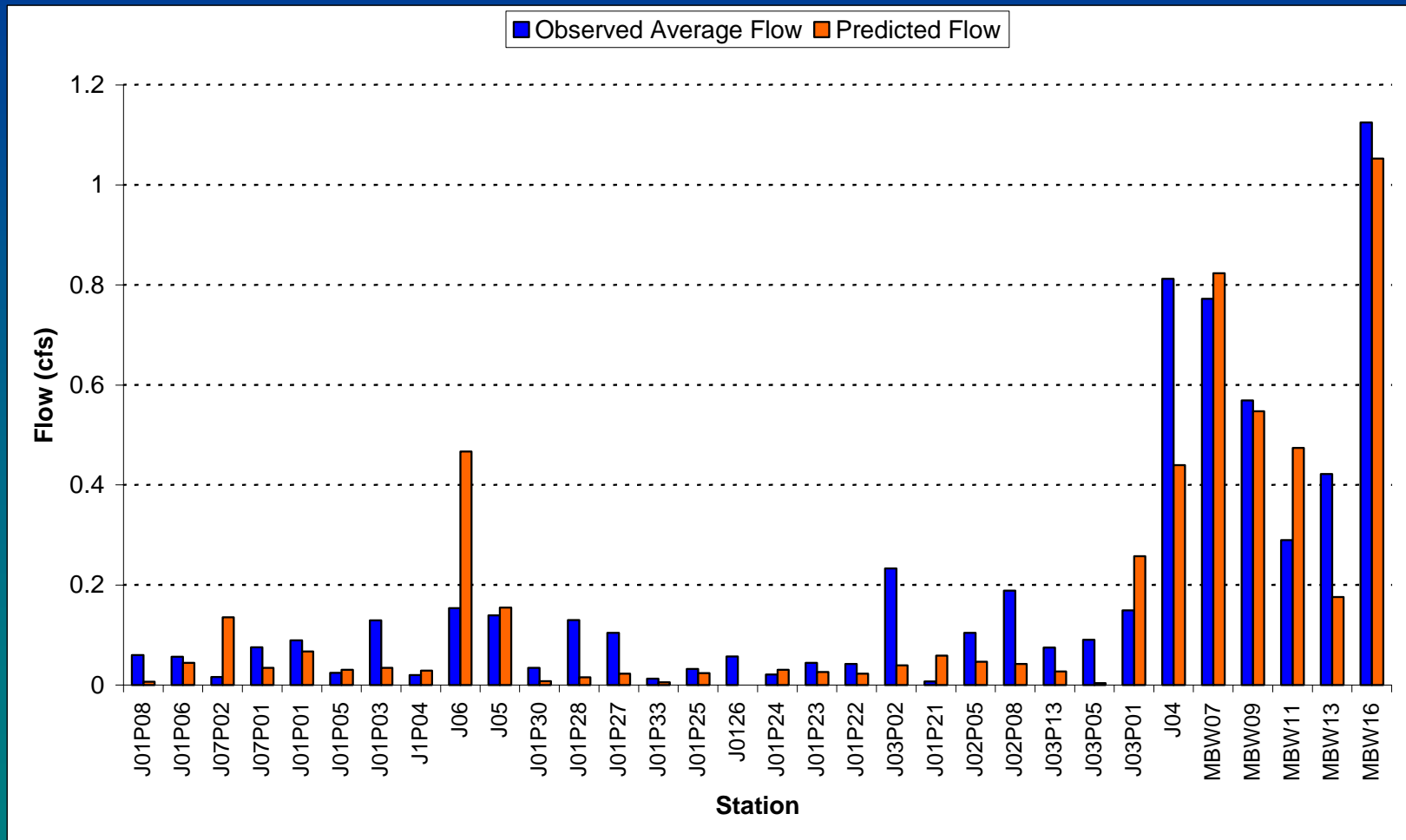
Q = flow (ft³/s)

A_{1400} = area of commercial/institutional (acres)

A_{4000} = area of open space, including military operations (acres)

A_{1500} = area of industrial/transportation (acres)

Dry Weather Data Analysis



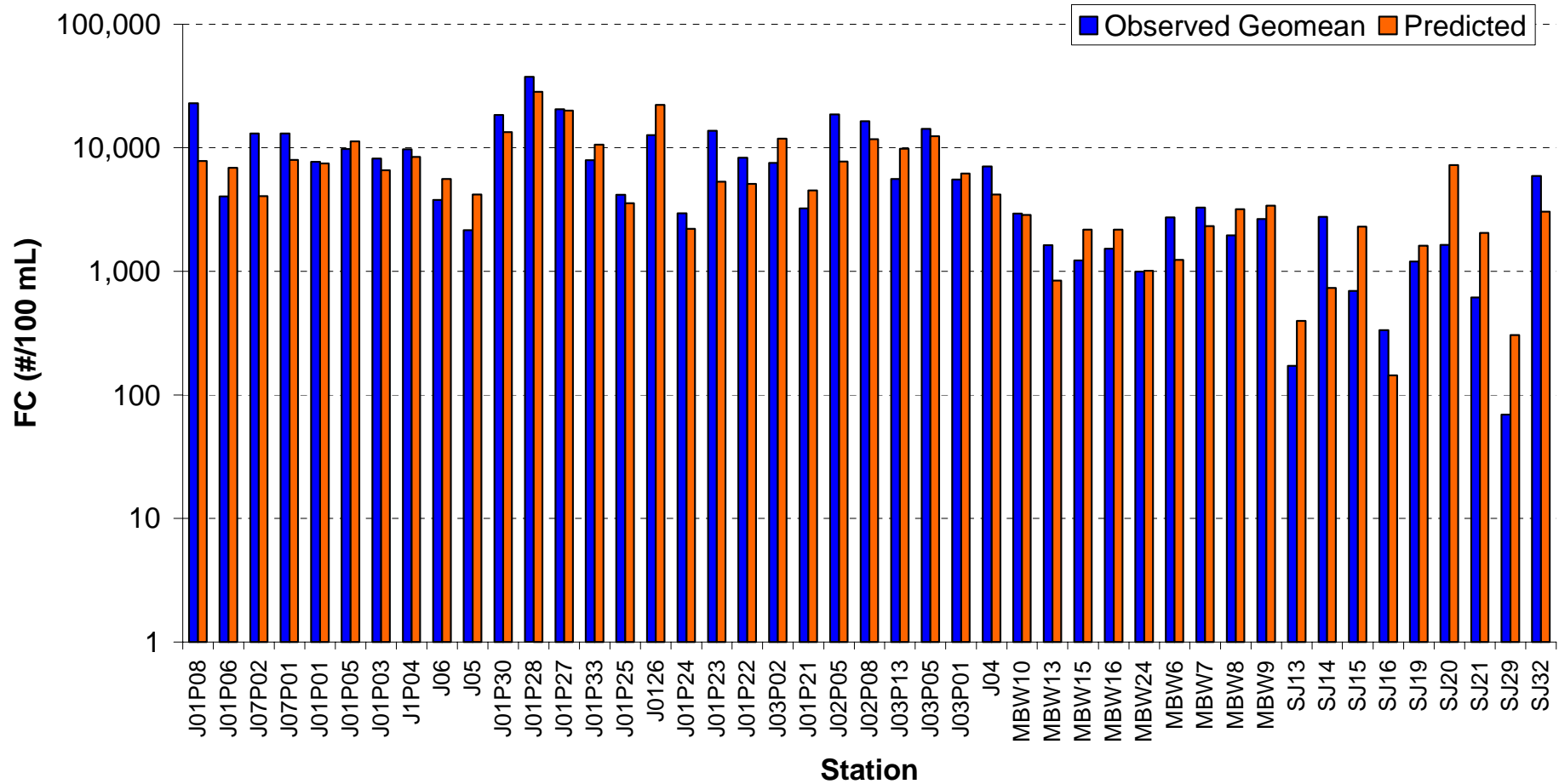
Dry Weather Water Quality Data Analysis

- Analysis was performed to determine relationship between dry bacteria concentrations and land use within respective subwatersheds
- Geometric mean of bacteria concentrations determined where data was plentiful
 - 27 stations at Aliso Creek
 - 4 stations at Rose Creek
 - 5 stations at Tecolote Creek
 - 9 stations at San Juan Creek
- Multivariable regression analysis performed relating land use distributions and drainage area to FC ($R^2 = 0.74$)

$$\begin{aligned} \ln(FC) = & 8.48 \times (\%LU_{LDR}) + 9.81 \times (\%LU_{HDR}) + 8.30 \times (\%LU_{IND}) + 8.46 \\ & \times (\%LU_{OPS}) + 10.76 \times (\%LU_{TRN}) + 6.60 \times (\%LU_{COM}) + 17.92 \times (\%LU_{PRK}) \\ & + 12.85 \times (\%LU_{OPR}) - 0.000245 \times A \end{aligned}$$

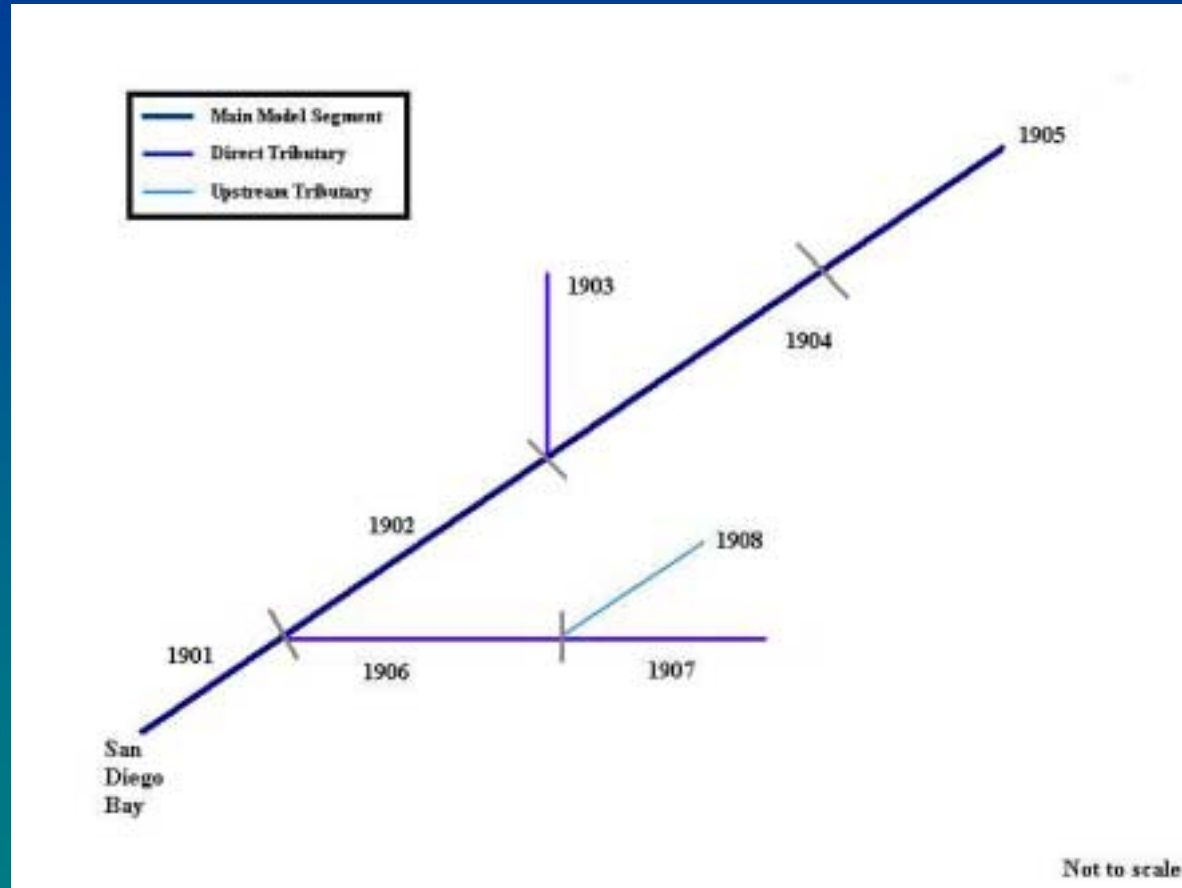
- Similar relationships established for TC and ENT

Dry Weather Water Quality Data Analysis



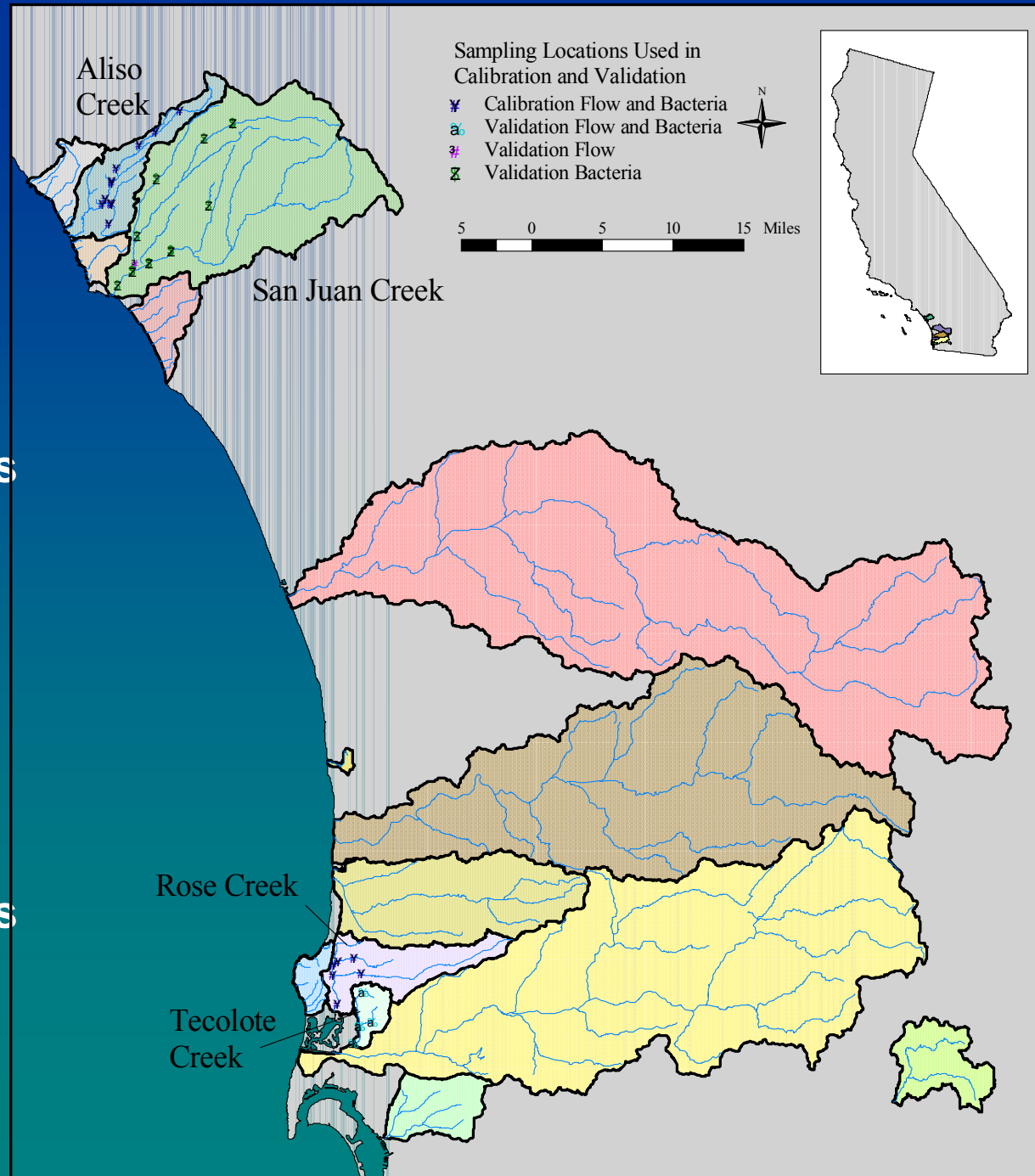
Model Configuration

- Subwatersheds consistent with wet weather approach
- Subwatershed flows and bacteria concentrations determined using empirical equations
- Streams model as plug flow reactors
 - 1st order die-off of bacteria
 - Stream infiltration function of streambed area (inches/day)



Model Calibration and Validation

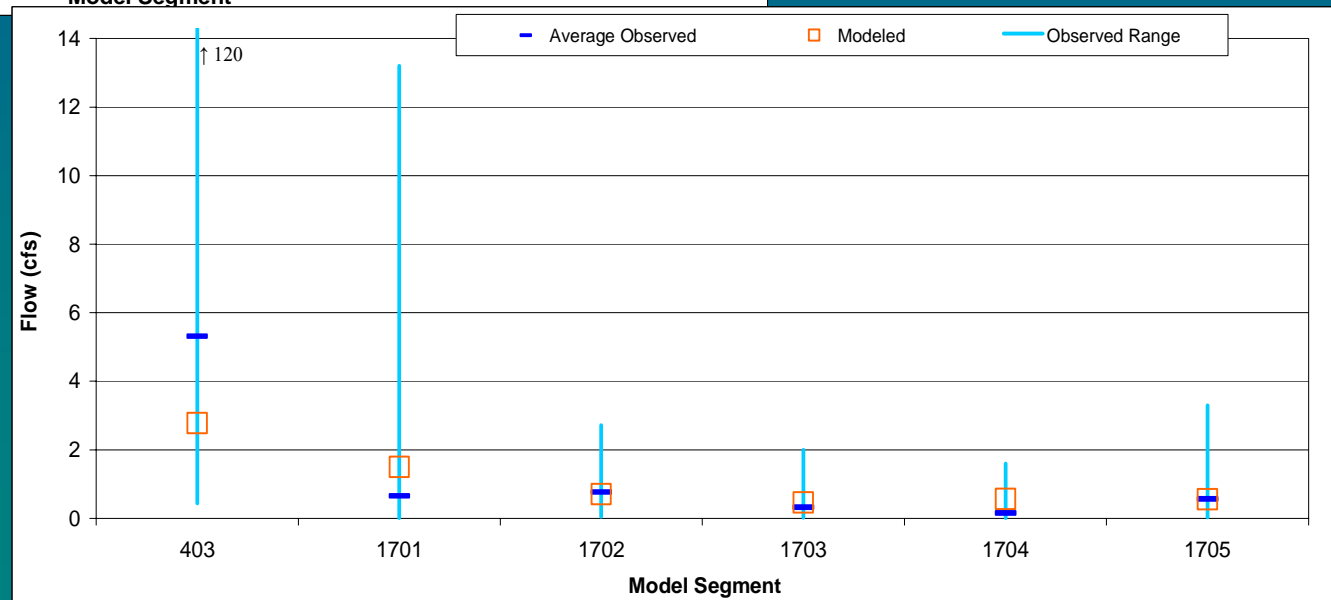
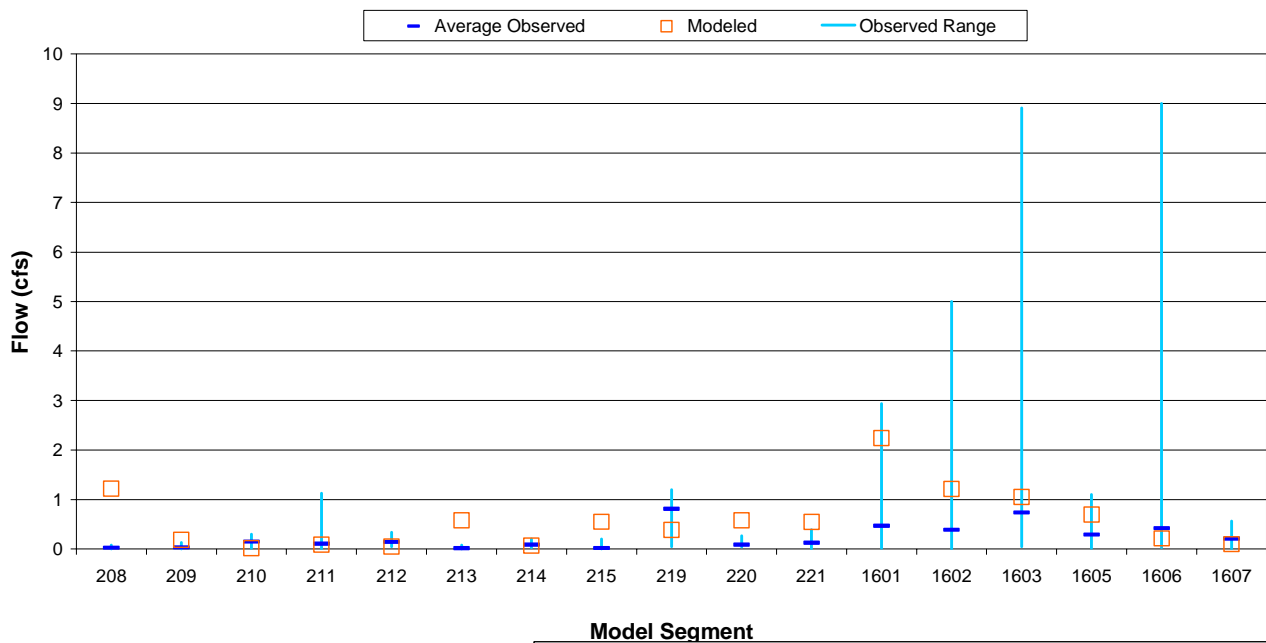
- Flow calibration
 - Model-predicted streamflows compared to ranges of observed data
 - Infiltration rates adjusted
- Water quality calibration
 - Model-predicted bacteria levels compared to ranges of observed data
 - Die-off rates adjusted



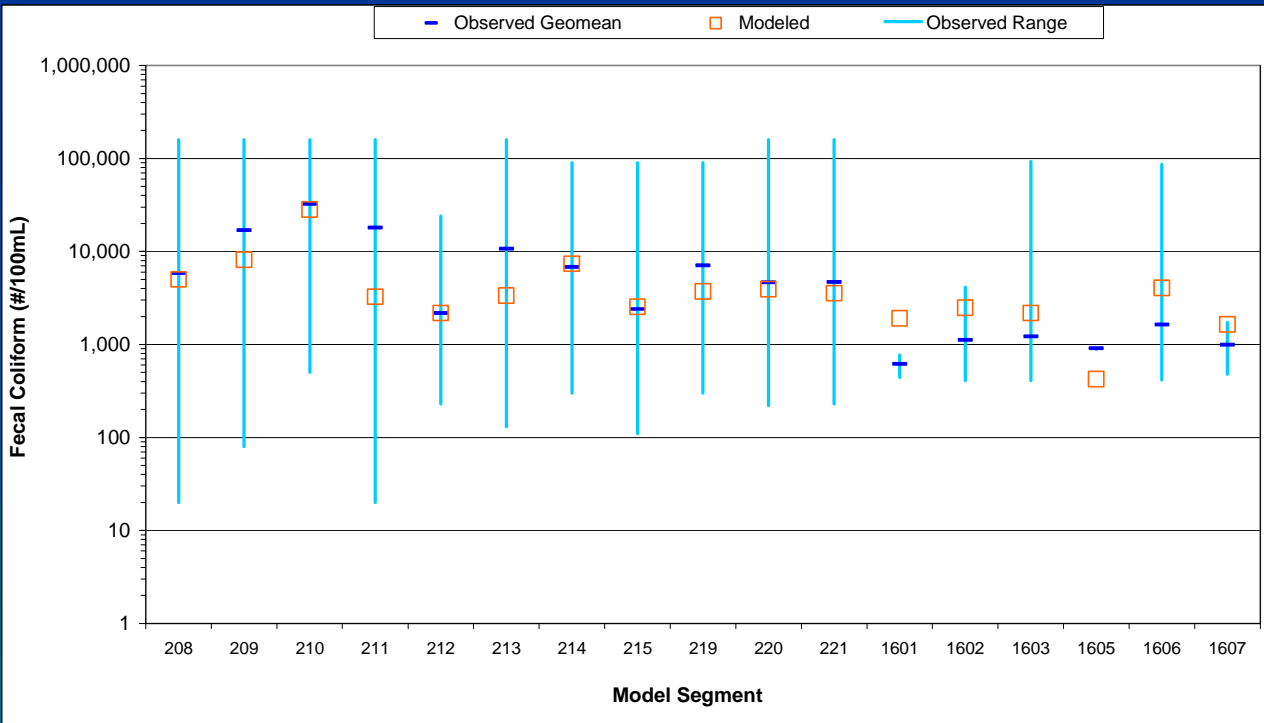
Flow Calibration and Validation

Resulting infiltration rates:

- 1.368 in/hr (Soil Group A)
- 0.698 in/hr (Soil Group B)
- 0.209 in/hr (Soil Group C)
- 0.084 in/hr (Soil Group D)

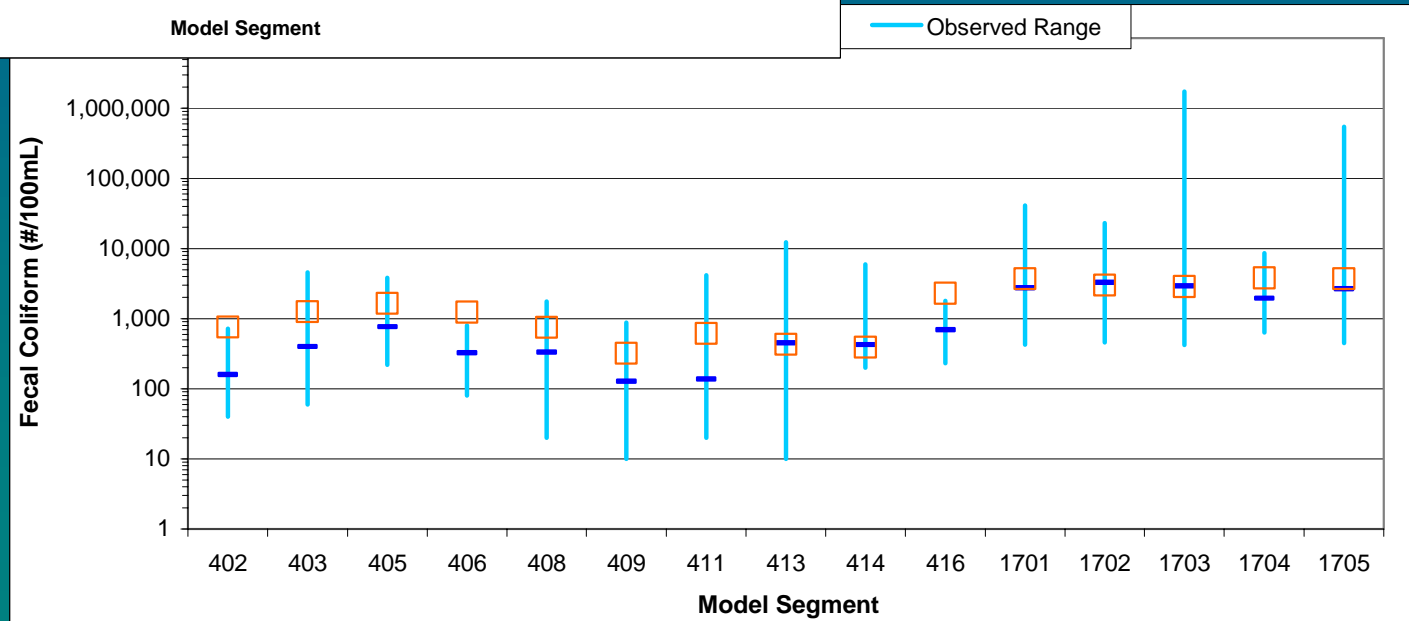


Water Quality Calibration and Validation



Resulting bacteria die-off rates:

- FC - 0.137 1/d
- TC - 0.209 1/d
- ENT - 0.145 1/d



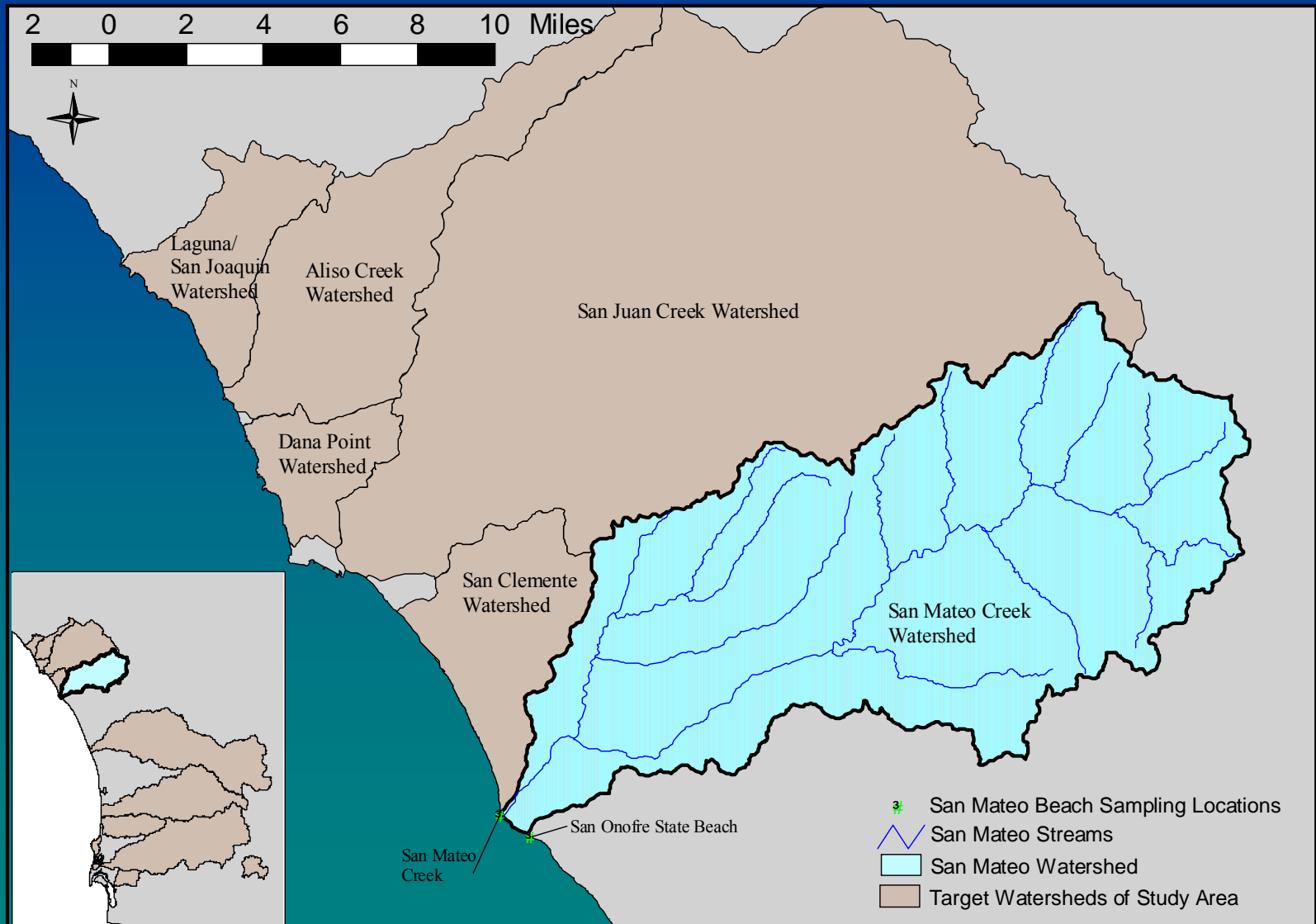
Model Application

- Simulated steady-state flows and bacteria levels occurring during typical dry periods for all watersheds impacting impaired waterbodies
- Required reductions based on direct comparison of model-predicted bacteria levels to TMDL targets

Dry Weather TMDL Targets

- Reference watershed (San Mateo Creek) showed no exceedances of water quality objectives during dry conditions
- TMDL targets based on Basin Plan water quality objectives:
 - Beaches: REC-1 for FC and ENT; SHELL for TC
 - Inland Surface Waters: REC-1 for FC, TC, and ENT
- Interim targets were selected to provide sufficient time for further study
 - REC-1 for TC

Reference Watershed – San Mateo Creek



Summary of TMDL Results

- TMDLs reported for each watershed and associated impaired waterbodies
- All loads expressed as basinwide wasteload allocations (WLAs) to MS4 permits (point sources)
- No load allocations reported (nonpoint sources)

Example TMDL Results

Hydrologic Descriptor	Wet Weather TMDL Results							Dry Weather TMDL Results			TMDL (Billion MPN/year)
	Model Subwatershed ^a	Waste Load Allocation (Billion MPN/year)	Total Load for Existing Condition (Billion MPN/year)	Percent Reduction ^b	Basinwide Waste Load Allocation (Billion MPN/year)	Basinwide Existing Load (Billion MPN/year)	Basinwide Percent Reduction	Basinwide Waste Load Allocation (Billion MPN/year)	Basinwide Existing Load (Billion MPN/year)	Basinwide Percent Reduction	
San Joaquin Hills HSA (901.11) & Laguna Beach HSA (901.12) Cameo Cove at Irvine Cove Dr. - Riviera Way at Heisler Park – North	101	309	5,179	95%	1,181	52,676	97.9%	154	5,041	97.0%	1,335
	103	872	47,497	98%							
Laguna Beach HSA (901.12) at Main Laguna Beach Laguna Beach at Ocean Avenue Laguna Beach at Laguna Ave. Laguna Beach at Cleo Street Arch Cove at Bluebird Canyon Rd. Laguna Beach at Dumond Drive	104	10,505	592,496	98%	15,611	652,339	97.7%	2,083	21,998	90.5%	17,694
	105	4,174	47,842	92%							
	106	932	12,001	93%							
Aliso HSA (901.13) Laguna Beach at Lagunita Place / Blue Lagoon Place at Aliso Beach Aliso Creek	201	630	19,386	97%	105,422	1,752,095	95.2%	2,383	51,446	95.4%	107,805
	202	104,792	1,732,709	95%							
Dana Point HSA (901.14) Aliso Beach at West Street Aliso Beach at Table Rock Drive 1000 Steps Beach at Pacific Coast Hwy at Hospital (9th Ave) at Salt Creek (large outlet) Salt Creek Beach at Salt Creek service road Salt Creek Beach at Dana Strand Road	301	507	12,677	97%	22,317	403,911	94%	911	18,263	95.0%	23,228
	302	715	13,426	95%							
	304	19,885	356,926	96%							
	305	367	10,149	96%							
	306	843	10,733	92%							
Lower San Juan HSA (901.27) San Juan Creek	401	381,639	15,304,790	98%	381,639	15,304,790	98%	16,038	62,179	74.2%	397,677